

**GCES Phase II Annual Report
1992 Research**

Habitat use by humpback chub, *Gila cypha*, in the Little Colorado River and other tributaries of the Colorado River in the Grand Canyon

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RESEARCH OBJECTIVES

Determine habitat use by humpback chub and other native fishes in the Little Colorado River (LCR) and other tributaries of the Colorado River in the Grand Canyon; evaluate the potential for establishing a second spawning aggregation of humpback chub; and from the perspective of habitat requirements, evaluate how native fishes are affected by the operation of the Glen Canyon Dam.

Specific Objectives

1. Determine habitat availability by measurement and mapping habitat in the LCR and other tributaries of the Colorado River.
2. Determine seasonal patterns of habitat use by juvenile and adult fishes in the LCR and other tributaries of the Colorado River.
3. Identify humpback chub spawning habitat in the LCR and potential spawning habitat in other tributaries of the Colorado River.
4. Predict the effects of seasonal and intermittent high discharges on habitat availability in the LCR by modeling studies.

USFWS RESEARCH IN THE LITTLE COLORADO RIVER

Field Research and Sampling Effort

Nine research trips were completed, totaling 69 days in the field in 1992 (Table 1). Sampling methodologies are described in detail in Gorman et al. (1992). Sampling efforts included measuring habitat at 615 ASU hoopnets, 913 FWS minihoop nets, 599 FWS minnow traps, 128 seine samples, and 306 habitat transects (Table 2). Despite ambitious sampling efforts in 1992, fish capture rates were low. Catch rates in minihoop nets were typically <.5 fish/set. Capture rates were highest in June when the LCR was at base flow for several weeks before the onset of the monsoons (Table 3).

As in 1991, speckled dace and humpback chub continued to be the predominant species in the LCR (Table 3). Most speckled dace captured during the months of August and September were taken in the Atomizer Falls to Blue Springs reach (km 14.5-21). It is notable that no humpback chub were taken in samples above Chute Falls (~ km 15), but 3 chubs were taken in the vicinity of Chute Falls (~ km 14.5). Compared to this upper reach, speckled dace are not as abundant in downstream reaches of the LCR. During periods of sustained flooding in downstream reaches,

TABLE 1. USFWS Research in the LCR: 1992 Field Schedule.

dates	trip duration (days)	number of personnel
12 - 19 February	7	7
5 - 10 March	5	2
26 March - 2 April	7	2
22 - 29 April	7	5
15 - 24 June	9	5
14 - 23 July	9	5
12 - 19 August	7	6
23 September - 2 October	9	9
9 - 17 November	9	4
total	69	

TABLE 2. USFWS Research in the LCR: 1992 Fish Sampling Effort and Habitat Measurements.

date of trip	ASU hoopnet	FWS minihoop	FWS minnow trap	FWS seine haul	FWS habitat transects
12 - 19 February	20	133	130	0	32
5 - 10 March	29	na	na	na	0
26 March - 2 April	51	na	na	na	0
22 - 29 April	156	na	na	na	71
15 - 24 June	105	180	162	0	61
14 - 23 July*	108	145	83	0	34
12 - 19 August*	77	203	94	0	44
23 Sept. - 2 Oct.*	na	160	74	78	32
9 - 17 November	69	92	56	50	32
totals	615	913	599	128	306

*Includes samples taken by Bill Mattes, ACFWRU Graduate Student, from the Atomizer Falls to Blue Springs reach (km 14.5-21).

TABLE 3. USFWS Research in the LCR: Summary of Fish Captures.

species	dates						species totals
	Feb	Jun	Jul	Aug*	Sep*	Nov	
Rainbow trout	0	0	0	0	0	0	0
Humpback chub	33	405	31	37	134	53	693
Bluehead sucker	0	32	1	1	6	6	46
Flannelmouth sucker	2	11	0	0	4	0	17
Speckled dace	31	707	303	167	324	28	1560
Fathead minnow	0	4	0	6	21	1	32
Plains killifish	0	0	0	0	1	0	1
Carp	0	0	0	1	13	0	14
Channel catfish	0	0	0	1	5	1	7
monthly totals	66	1159	335	213	508	89	2370

*Includes samples taken by Bill Mattes, ACFWRU Graduate Student, from the Atomizer Falls to Blue Springs reach (km 14.5-21).

humpback chub was the predominant species captured in hoopnets and minnow traps. Apparently, humpback chub are more active than other species during flood conditions when the LCR has a high load of suspended solids. We believe that our 1992 sampling underrepresents the abundance of bluehead and flannelmouth suckers. Most of the fishes from the September trip were taken in seine sampling; this reflects the need for active rather than passive sampling methods during flood conditions.

The increase in abundance of fathead minnows and the presence of young-of-year common carp and channel catfish in the September sampling effort immediately followed the largest flood in the LCR in 1992 (>6000 cfs). Most of these exotics were taken in areas above Chute Falls. These species were perhaps flushed downstream from areas above Blue Springs. This pattern of capture suggests that these exotics reproduce in upstream portions of the LCR drainage and are flushed into the perennially flowing lower portion by monsoon triggered spates.

Two juvenile chubs and one speckled dace were lost to incidental mortality in 1992. During the June field trip, one chub and the speckled dace were inadvertently left in minihoop nets that were pulled from the water. During the September trip, the other chub was lost when a minihoop net became buried during flooding.

Mapping and Surveys in the Little Colorado River

All FWS transect markers were field checked and have been located on a GCES base map. This provisional map has been distributed to ASU/NFWD personnel. During the September 23-October 2 field trip, GCES surveyors conducted a survey of the LCR channel. FWS personnel provided assistance and logistic support for this effort. The survey included the locations of all FWS transects from Blue Springs to the confluence. A high resolution map of the LCR channel with FWS transect locations is currently being prepared by GCES.

Water Quality of the Little Colorado River

The LCR was above base flow throughout most of 1992; regular spates and periods of prolonged flooding were the rule. During February-April, discharge typically ranged from 1000-3000 cfs. A brief pre-monsoon dry period in June allowed the river to run at base flow (~ 200 cfs) for several weeks. With the arrival of the monsoons the river flushed regularly, with peak discharges >3000 cfs. The largest flood occurred on 20 September, when the LCR peaked at over 6000 cfs. The water was generally very turbid and silt laden, dissolved oxygen levels were at saturation, water temperatures ranged from 8°C to 26°C, and conductivity ranged from 200-4000 mMHOs. Conductivity was generally 1000 or less as runoff from the LCR basin diluted the saline bicarbonate waters that discharge from Blue Springs.

USFWS RESEARCH IN OTHER TRIBUTARIES

Delays in permit approvals delayed the start of sampling on the smaller tributaries of the Colorado River in the Grand Canyon. All small tributaries were sampled at least once in 1992, and the Paria River was sampled on a monthly basis (Table 4a and 4b). Habitat and fish capture data have been entered into DBASE files but no analysis has been done. The native fishes, speckled dace, bluehead sucker, and flannelmouth sucker, were relatively common and abundant in most of the tributaries (Table 5). Common widespread exotics included brown and rainbow trout. Notable fish captures included a large adult humpback chub (435 mm TL) taken in the confluence area of Shinumo Creek. The chub had a yellow Carlin tag (#668 or #899?) inserted in the dorsal hump. Hoopnets set in the confluence of Shinumo Creek also captured a juvenile humpback chub (100mm TL). Two large channel catfish (593 and 650 mm TL) were seined from Kanab Creek. The stomach of the larger catfish contained a partially digested bluehead sucker (245 mm TL).

TABLE 4a. USFWS Research in the Smaller Tributaries of the Colorado River in the Grand Canyon: 1992 Field Schedule.

tributary	month	habitat measures	fish sampling	sampling duration (days)
Paria River	Jan-Feb-May-June-June-July-Aug-Sep-Oct-Nov	transects (10 km)	seining	34
Bright Angel Creek	Jan-June-Oct-Dec	transects (10 km)	seining snorkel survey drift nets	37
Shinumo Creek	Aug-Oct-Dec	transects (10 km)	snorkel survey seining minihoop nets minnow traps	4
Tapeats Creek	Aug	transects (4 km)	snorkel survey	2
Deer Creek	Aug	transects (90 m)	snorkel survey	1
Kanab Creek	Aug-Oct	transects (10 km) minihoop nets	seining minihoop nets minnow traps drift nets	6
Havasu Creek	Aug-Oct	transects (5.3 km) minihoop nets	seining minihoop nets minnow traps	9

TABLE 4b. USFWS Research in the Smaller Tributaries of the Colorado River in the Grand Canyon: 1992 Fish Sampling Effort and Habitat Measurements.

date of trip	minihoop/ minnow trap	seine	shock	snorkel	habitat transects
January		5	5		41
March		11			20
May		17			
June		15			109
July				25	30
August	55	45		20	190
September		24		40	21
October	31			13	11
November		37			77
totals	86	154	5	97	499

TABLE 5. USFWS Research in the Smaller Tributaries of the Colorado River in the Grand Canyon: Summary of Fish Captures.

tributary	species*									
	HBC	SPD	BHS	FMS	FHM	CCF	CRP	BNT	RBT	CUT
Paria		1974	1	137					2	
Bright Angel		21	2					216	57	1
Shinumo	2	936	86	10	1	1	1	4	111	
Tapeats									175	
Deer									66	
Kanab		278	195	10	34	4	2		1	
Havasu		350	73		3				1	
totals	2	3359	357	157	38	5	3	220	413	1

*HBC-humpback chub; SPD-speckled dace; BHS-bluehead sucker; FMS-flannelmouth sucker; FHM-fathead minnow; CCF-channel catfish; CRP-common carp; BNT-brown trout; RBT-rainbow trout; CUT-cutthroat trout.

TABLE 6. USFWS Research in the LCR: Summary of Similarity (PS)* Measures for LCR River Segments 0-21 km and USFWS Study Areas.

Statistics for LCR km 1-21 PS Measures				
	Depth	Current	Substrate	Combined (DCS)
mean	0.79	0.79	0.66	0.75
median	0.80	0.80	0.67	0.75
SD	0.036	0.043	0.038	0.024
SEM	0.008	0.009	0.008	0.005
range	0.13	0.19	0.13	0.08
min	0.70	0.64	0.59	0.71
max	0.83	0.83	0.72	0.79
USFWS Study Areas				
Powell	0.80	0.77	0.64	0.73
Salt	0.79	0.80	0.64	0.74
Confluence (km 0)	0.64	0.46	0.65	0.59

*Maximum PS value is 1 (identity). Combined represents the mean similarity for depth, current, and substrate PS measures (DCS). Similarity matrices upon which this is based are presented in Appendix I.

ANALYSIS OF DATA

All USFWS habitat and fish data is being entered into dBASE IV files. Analysis of habitat data will be conducted in the following order:

1. Descriptive statistics of FWS transect data
 - a. Base flow survey from July-Aug 1991, km 0-21.
 - b. Remeasured transects from FWS study areas: 12/91, 2/92, 4/92, 6/92, 7/92, 8/92, 9/92, 11/92.
 - c. Remeasured transects from Confluence (6/92)
2. Multivariate statistical analysis of FWS transect data
3. Habitat measurements from fish sampling
 - a. Habitat data from ASU hoopnets: 7/91, 8/91, 10/91, 2/92, 3/92, 4/92, 6/92, 7/92, 8/92, 9/92, 11/92.
 - b. Habitat data from FWS minihoops: 12/91, 2/92, 6/92, 7/92, 8/92, 9/92,

- 11/92.
- c. Habitat data from FWS minnow traps: 12/91, 2/92, 6/92, 7/92, 8/92, 9/92, 11/92.
 - d. Habitat data from FWS seining: 7/91, 8/91, 9/92, 11/92.
4. Multivariate statistical analysis of habitat from fish sampling
 5. Habitat availability/sampling bias analysis. Appropriateness of habitat sampled from fish capture devices will be evaluated by comparison and grouped analyses of parts 1,2 vs. 3,4 above.
 6. Analysis of fish habitat use data. Data from parts 3, 4 will be evaluated in terms of species capture data. Selectivity, niche overlap, niche shifts, and ontogenetic changes will be evaluated. Procedures will include niche metrics and multivariate methods.
 7. Habitat and fish capture data from the tributaries will be analyzed in a manner like that used for the LCR data set. Multivariate methods will be used to determine which, if any, tributaries have habitat configurations and fish community structure similar to that in the LCR.

RESULTS and DISCUSSION

Habitat, Little Colorado River

At the time of this report most habitat and fish sampling data collected by USFWS researchers has been entered into dBASE IV computer files. The lack of fish data from 1991 habitat measurements and the poor catch rates for USFWS sampling throughout much of 1992 (because of frequent and prolonged flooding in the LCR) has left us with a meager habitat use data set. Preliminary univariate and multivariate analyses have been conducted on summer 1991 habitat transect data to characterize the upper, middle, and lower reaches of the LCR as well as the USFWS study areas. Initially, summer 1991 habitat data for each 1 km section of the LCR from the confluence (km 0) to Blue Springs (km 21) were analyzed (Fig 1). Mean depths were greatest at mid-reach (km 11-14) and at the confluence (km 0). Mean currents showed a complementary pattern and were lower at mid-drainage (km 13-15) and at the confluence (km 0). Mean substrate size was smaller in the upper reach and at the confluence, but standard errors were very large, often exceeding the value of the mean.

The pattern of mean habitat values reflect a change in habitat configuration from Blue Springs to the confluence (Fig 1). In the Blue Springs reach (km 20-21) mean depth was low (36-39 cm), currents were slow-moderate (2.4-2.5), and mean substrate size was small (2.6-3.4). This area of the LCR is characterized by shallow to moderate depth channels, sand and boulder substrates, and numerous springs. Below the Blue Springs reach (km 17-19) mean depth increased to 51-58 cm, mean currents remained similar (2.3-2.5), but mean substrate size increased slightly to a range of 2.9-3.5. This section

of the LCR is characterized by deep sand-bottomed pools against vertical canyon walls and fast riffles strewn with large rounded boulders. In the next downstream reach above Chute falls (km 15-16), travertine formations first appear in the LCR. Chute Falls represents the first large travertine dam complex in the upper LCR. Behind this dam the LCR channel widens and is choked with sand. The dam effect of Chute Falls goes as far upstream as km 17 were the LCR channel makes a sharp horseshoe bend. The range of mean depths in the above Chute Falls reach decreased to 36-38 cm, as did mean currents (1.6-2.6) and mean substrates (2.0-3.2). The Big Canyon-Atomizer Falls (km 11-14) reach contains all the large travertine dam complexes of the LCR. This area is characterized by large travertine reefs, dams, and ridges interspersed with shallow to deeply scoured sand-bottomed pools. Compared to the above Chute Falls reach, mean depths and substrates increased in the Big Canyon to Atomizer Falls reach (53-68 cm, 2.2-5.8, respectively), while mean currents remained similar (1.8-2.4). The Sipapu to Salt Camp reach (km 7-10) was notably shallower than Big Canyon-Atomizer Falls reach, with mean depths ranging from 38-58 cm and mean substrates were smaller (2.7-5.0). However, the range of mean currents (1.9-2.5) was similar. The Sipapu to Salt Camp reach is characterized by low travertine reefs and dams with intervening long shallow runs, races and pools. In Powell Canyon to Sipapu reach, the mean currents were greater (2.2-2.6), but the range of mean depths and substrates were similar (38-52 cm and 3.3-5.1, respectively). This reach has a similar habitat configuration as the Sipapu to Salt Camp reach. The confluence to Powell Canyon reach (km 1-2) had similar ranges of mean depths (45-47 cm) and substrates (3.9-4.2) but had greater mean currents (2.4-2.9). This lower reach has a gross habitat configuration similar to the two upstream reaches. The final reach, the confluence (km 0), was markedly different from the others; the influence of backwatering of the Colorado River is evident. Mean depth was greater (62 cm), mean currents were much slower (1.3), and mean substrate sizes were much smaller (3.3).

Frequency distributions of the three major habitat dimensions (depth, current, substrate) provided profiles of stream habitat for the LCR (km 0-21) and for each of the study areas (Fig. 2, 3). Overall, most stream habitats had depths of <60 cm and most currents ranged from 1 (very slow or <.15 m/sec) to 3 (moderate or .35-.75 m/sec). Substrates showed a non-normal, strongly bimodal distribution dominated by sand (substrate 2) and travertine (substrate 10). To investigate the similarity of habitats among the 1 km reaches and the study areas, frequency distributions of habitat variables for km reach and study area were generated (Appendix A). Matrices of percent similarity (PS) measures comparing habitat dimensions for all river sections and study areas were generated (Appendix B). A summary of this analysis is presented in Table 6. The study area reaches (Powell Camp, 2.5-3.5; Salt Camp 10.5-11.5) were most similar to neighboring reaches of the LCR. The patterns of similarity (or differences) among the km sections reflect the just discussed changing character of the river channel from Blue Springs to the confluence. As expected, the confluence stands out as being very different from the upstream reaches of the LCR.

To gain more insight as to the changing nature of the habitat in the LCR, a principal component analysis was conducted on the entire 1991 habitat transect data set (Table 7). The first principal component explained 37.5% of the variance and represented a stream

channel cross-sectional gradient of habitats that ranged from still, shallow areas with fine substrates (edges) to center channel areas of deeper water, faster currents and larger substrates. The second principal component explained 26.4% of the variance and represented a upstream-downstream longitudinal gradient of pool habitat types. Pools in upstream areas were characterized by smaller substrates and increasing depths to downstream areas of larger substrates and decreasing depth. This pattern reflects the presence of deep, scoured, sand-bottomed pools along vertical canyon walls and below travertine dams in the upper portion of the LCR whereas in the lower portion the pools are shallower and are strewn with boulders and travertine reefs. The third principal component explained 23.1% of the variance and represented a upstream-downstream gradient of travertine dam/reef/riffle habitat types. Travertine dams and reef complexes were more expansive in the middle and upper LCR (especially km 11-15) than those in the lower LCR and is reflected as larger substrates and reduced depths in the upstream reaches.

Scatterplots of the habitat data on the first two principal components are shown for the lower LCR (km 0-7.5; Fig. 4), middle LCR (km 8.0-14.5; Fig. 6) and the upper LCR (km 15-21; Fig 8). Differences in loadings along principal component 2 permitted some discrimination among the river reaches; upstream reaches have more deep pools with fine substrates. To graphically assess the representativeness of the study areas relative to their section of the river, scatterplots of habitat data from the study areas were compared with those for the associated river sections. The Powell Camp study area scatterplot (Fig. 5) has the same general shape and represents a subset of the central portion of the 0-7.5 km scatter plot (Fig. 4). The Salt Camp study area habitat data (Fig. 7) shows a similar high affinity to its associated river reach (km 8.0-14.5 scatterplot; Fig. 6).

These analyses represent only the first stage of preliminary analyses of LCR habitat data. A simple univariate analysis of habitat data from ASU hoopnets shows that these nets are set in habitat patches that generally are deeper and contain more large substrates than the available habitats in the LCR. Future reports will present more elaborate analyses of habitat data.

Hydrology

Compared to 1991, 1992 represents a near opposite hydrological year for the LCR. In 1991, the LCR remained at base flow from spring through the late fall. Starting in December 1991, the LCR has flooded regularly and discharge has mostly been above base flow. As a result of regular and prolonged input of upper drainage runoff, the upper LCR has transported a tremendous load of sediment into the lower river channel. The effect of Blue Springs discharge on the lower LCR has been minimized in 1992; the water of the river has been extremely turbid and silt laden on a near continuous basis, the conductivity was very reduced (typically 1/4 or less of its normal level), and formation of new travertine was not apparent while erosion of old travertine was evident.

Reproduction of native fishes

The strong 1991 year class of humpback chub indicates that reproduction of native fishes

was very successful in 1991. Fish sampling in the spring of 1992 by ASU researchers indicated that humpback chub had spawned in the LCR. However, 1992 reproduction of native fishes in the LCR appears to be a near-complete failure. The reasons for this failure are evidently tied to the regular and prolonged flooding in the LCR throughout most of 1992. Despite the reproductive failure of 1992, 1991 year class humpback chub remained abundant in the LCR throughout all of 1992. It is hoped that better hydrological conditions and closer coordination among research entities will improve chances of documenting habitat use by spawning chubs in 1993.

Habitat and habitat use by native fishes

Although the data have not been analyzed, the arrays of habitats in 1991 vs. 1992 were very different. Stream habitats were deeper, faster, and dominated by sand and silt substrates in 1992. The high turbidity and silt loads evidently affected fish activity levels and habitat use. During periods of high discharge and high silt loads, our passive sampling devices captured very few fish. During short periods of base flow (e.g., June 1992) catch rates increased 4-20 fold. Most of the fish taken in our September and November trips were sampled by active sampling devices (seines). During periods of declining sediment loads and turbidity, humpback chub were the first species to show increased activity. We suspect that high sediment loads in the flooding LCR may place a respiratory stress on resident fishes. These fish must secrete more mucus to keep the gill filaments cleared and this may reduce their respiratory capacity and subsequently their activity levels. In other words, when the LCR floods, fishes "hunker-down."

The abundance of 1991 year class humpback chub in the LCR throughout 1992 is noteworthy. Apparently, juvenile chubs have the capacity to dwell and thrive in the LCR under conditions of regular and prolonged flooding.

Future objectives

The last field season for Service involvement in GCES phase II research occurs during 1993. During this last year of field work we will initiate river hydraulic modeling research and evaluate the feasibility of developing habitat models using instream flow methodologies. Hopefully, this year will be a more "normal" hydrological year. At this point in our contracted research we have not collected the required critical habitat use data, we do not have matching fish data for our 1991 habitat data, and because of continuous flooding in the LCR, our fish sampling efforts yielded very little remarkable data in 1992.

If 1993 is a more normal hydrological year for the LCR we should be successful in obtaining critical habitat use data for humpback chub. Additionally, increased cooperation between our research team and that of ASU and AZGF will increase the likelihood of success. In the event that 1993 proves to be another wet hydrological year, it is unlikely that sufficient habitat use data will be collected to assess the feasibility of establishing other self-sustaining populations of humpback chub.

TABLE 7. USFWS Research in the LCR: Summary of principal component analysis (PCA) of 1991 USFWS habitat transect data for km 0-21 of the LCR.

MATRIX TO BE FACTORED (VARIABLES)				
	RIVER KM	DEPTH	CURRENT	SUBSTRATE
RIVER KM	1.000			
DEPTH	0.001	1.000		
CURRENT	-0.067	0.384	1.000	
SUBSTRATE	-0.085	0.008	0.293	1.000
LATENT ROOTS (EIGENVALUES)				
	1	2	3	4
	1.502	1.056	0.922	0.520
COMPONENT LOADINGS				
	1	2	3	4
CURRENT	0.852	0.088	0.054	0.513
DEPTH	0.661	0.535	-0.335	-0.406
SUBSTRATE	0.544	-0.523	0.581	-0.303
RIVER KM	-0.206	0.699	0.685	0.019
VARIANCE EXPLAINED BY COMPONENTS				
	1	2	3	4
	1.502	1.056	0.922	0.520
PERCENT OF TOTAL VARIANCE EXPLAINED				
	1	2	3	4
	37.546	26.396	23.051	13.007
MATRIX OF RESIDUALS				
	CURRENT	DEPTH	SUBSTRATE	RIVER KM
CURRENT	0.000			
DEPTH	0.000	0.000		
SUBSTRATE	0.000	-0.000	0.000	
RIVER KM	-0.000	-0.000	-0.000	0.000
FACTOR SCORE COEFFICIENTS				
	1	2	3	4
CURRENT	0.567	0.083	0.059	0.986
DEPTH	0.440	0.506	-0.363	-0.780
SUBSTRATE	0.362	-0.496	0.631	-0.583
RIVER KM	-0.137	0.662	0.743	0.036

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FIGURE LEGENDS

FIGURE 1. Mean habitat values for depth (A), current (B), and substrate (C) for 1 km segments of the Little Colorado River (LCR). Kilometer sections are arranged from the confluence (km 0) to Blue Springs (km 21), the major source of perennial base flow for the lower LCR. Current and substrate values are categorical (Gorman and Karr, 1978). Error bars represent +1, -1 SEM. Note the extreme variation in mean substrate sizes among segments.

FIGURE 2. Frequency histograms for depth, current, and substrate for the perennial flowing portion of the LCR, km 0 to km 21 (confluence to Blue Springs). Currents are shown ranging from none (0) to torrent (5) (> 1.2 m/s) (Gorman and Karr, 1978). The modal current is 3 (moderate; 0.3-0.7 m/s). Substrates are an alluvial series (modified Wentworth scale) ranging from silt (0) to bedrock or travertine (10) (modified from Gorman and Karr, 1978). The most abundant substrates are sand (2) and travertine (10). Percent frequency data for each km segment and the study areas are presented in Appendix II.

FIGURE 3. Frequency histograms for depth, current, and substrate for USFWS study areas in the LCR. Study area 1 is in the Powell Camp reach, km 2.5-3.5. Study area 2 is in the Salt Camp reach, km 10.5-11.5.

FIGURE 4. Scatter plot of habitat data loadings on PCA axes 1 and 2 (factors 1 and 2, Table 7) for LCR habitat transects from the confluence (km 0) to the Sipapu (km 7.5)

FIGURE 5. Scatter plot of habitat data loadings on PCA axes 1 and 2 (factors 1 and 2, Table 7) for LCR habitat transects from USFWS Powell Camp study area (km 2.5-3.5).

FIGURE 6. Scatter plot of habitat data loadings on PCA axes 1 and 2 (factors 1 and 2, Table 7) for LCR habitat transects from the Sipapu (km 8.0) to Atomizer Falls (km 14.5).

FIGURE 7. Scatter plot of habitat data loadings on PCA axes 1 (factors 1 and 2, Table 7) for LCR habitat transects from USFWS Salt Camp study area (km 10.5-11.5).

FIGURE 8. Scatter plot of habitat data loadings on PCA axes 1 (factors 1 and 2, Table 7) for LCR habitat transects from Chute Falls (km 15.0) to Blue Springs (km 21).

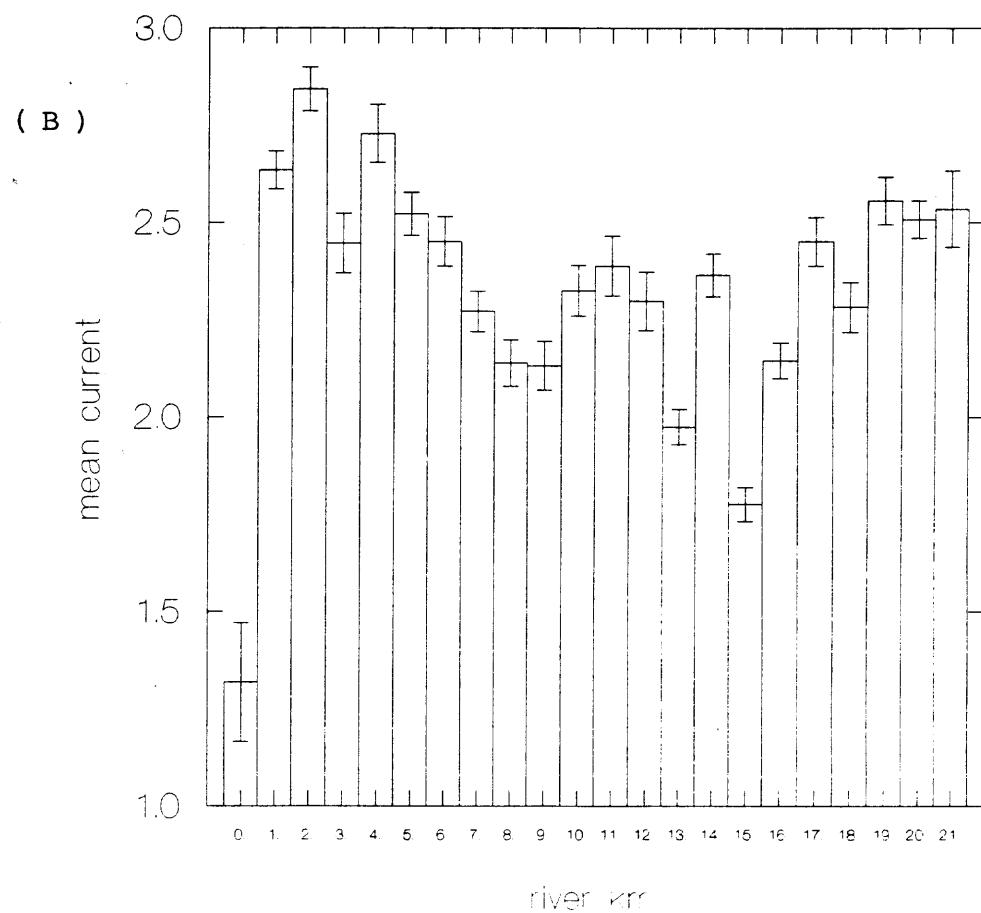
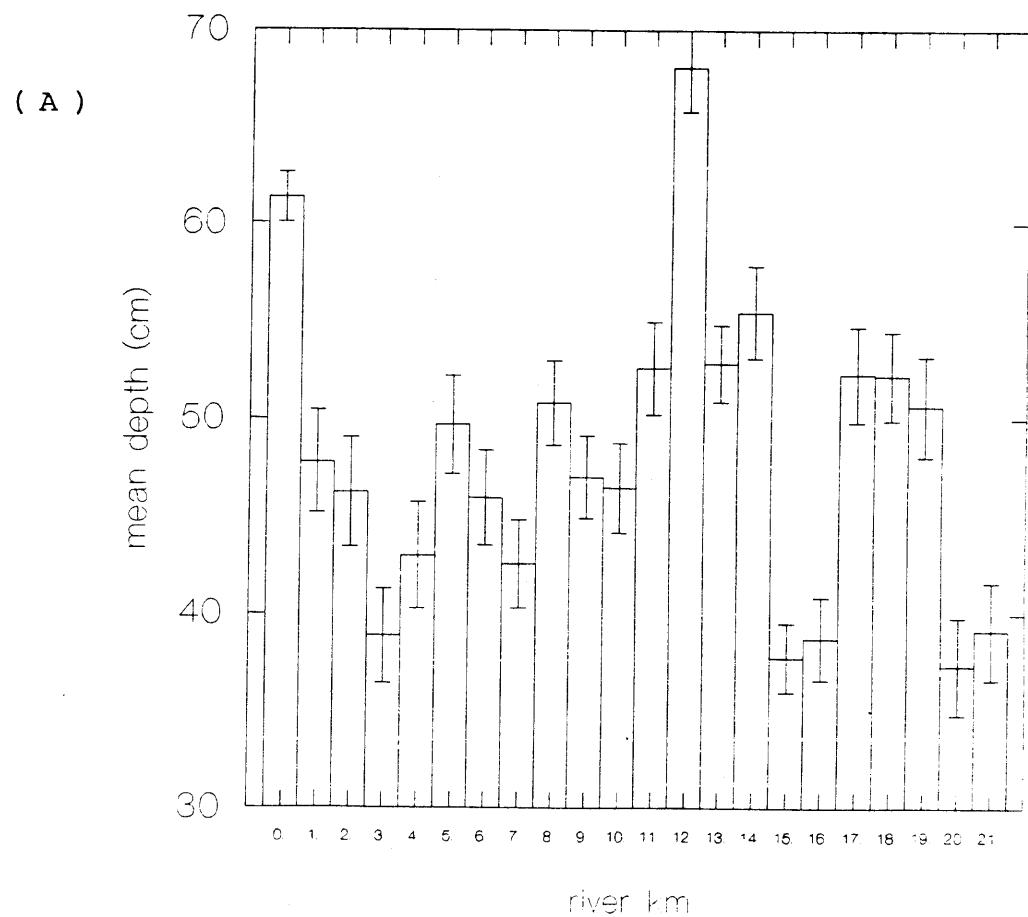


FIGURE 1

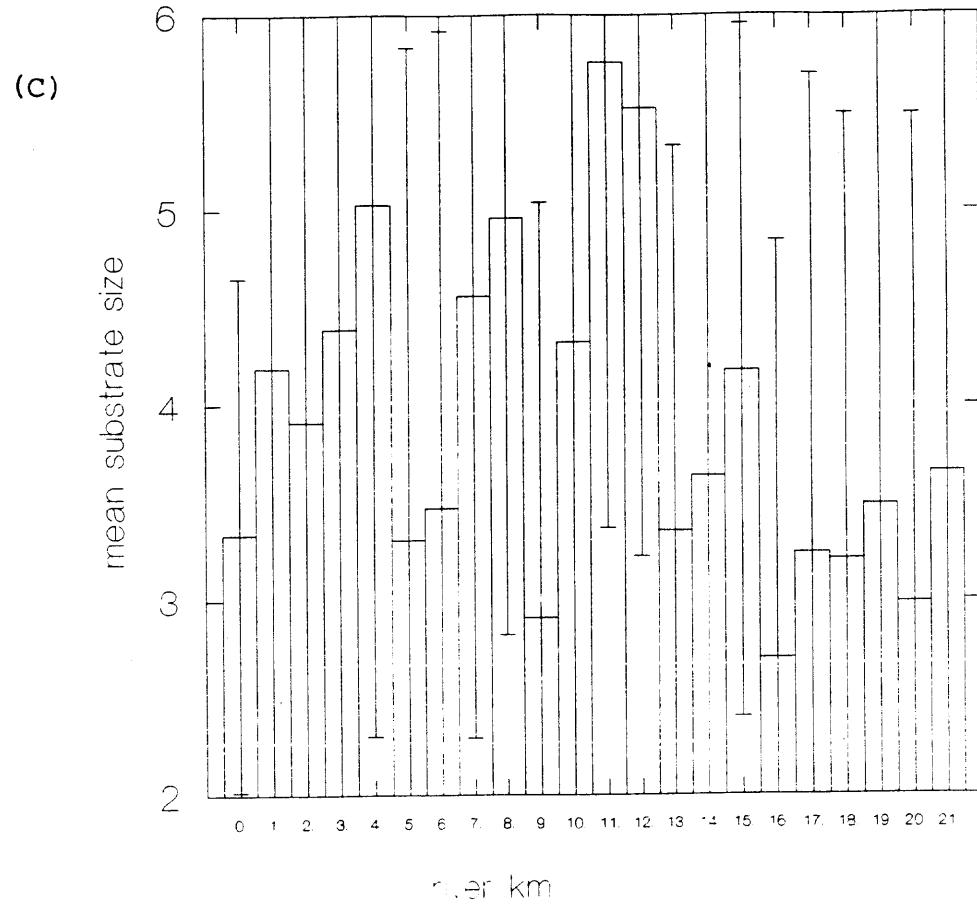
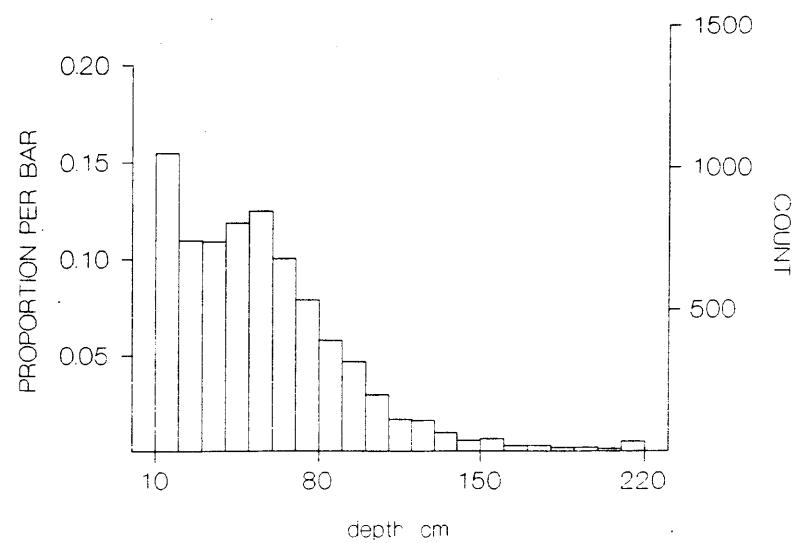


FIGURE 1

LCR, 100m transects, DEPTH



LCR, 100m transects, CURRENT -

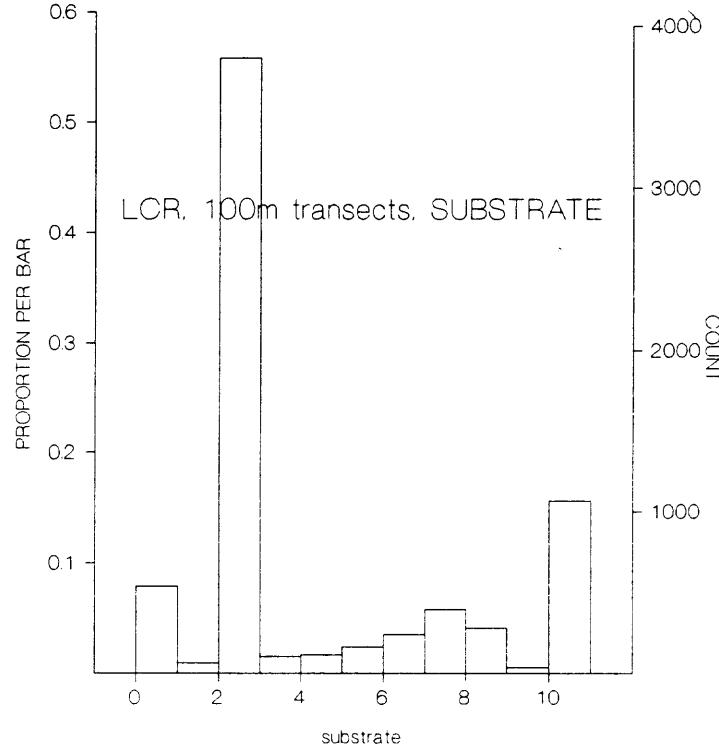
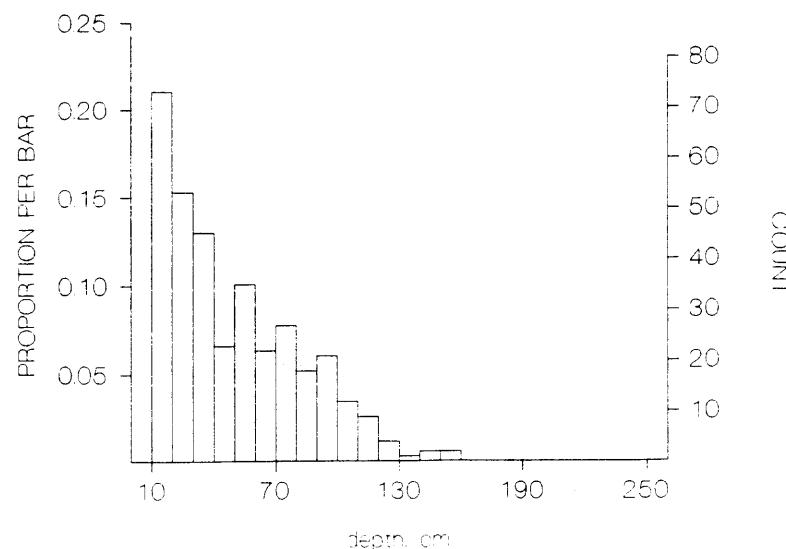
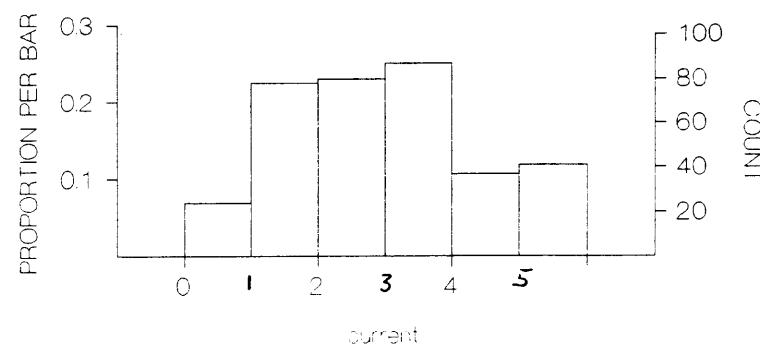


FIGURE 2

LCR, USFWS study area 1



LCR, USFWS study area 1



LCR, USFWS study area 1

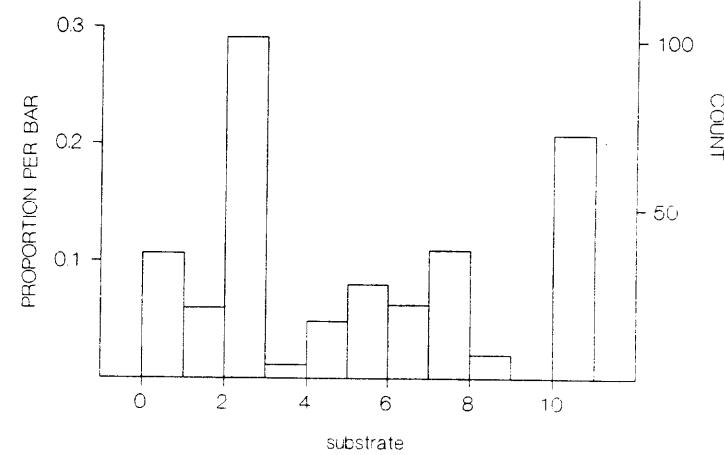
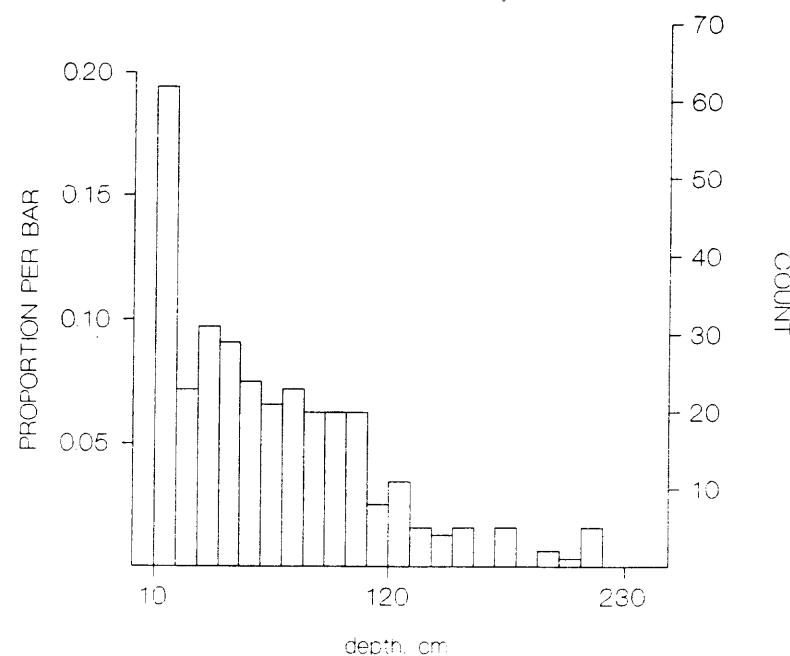
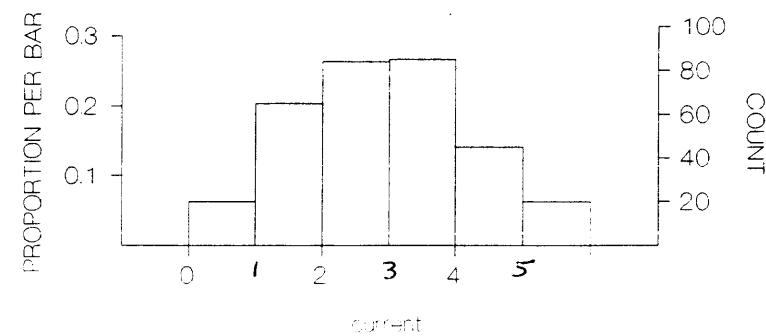


FIGURE 3

LCR, USFWS study area 2



LCR, USFWS study area 2



LCR, USFWS study area 2

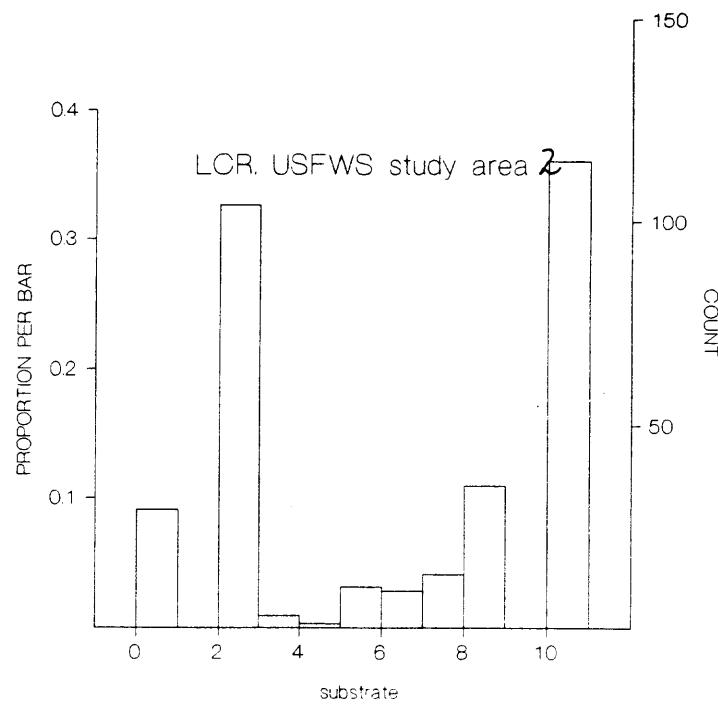
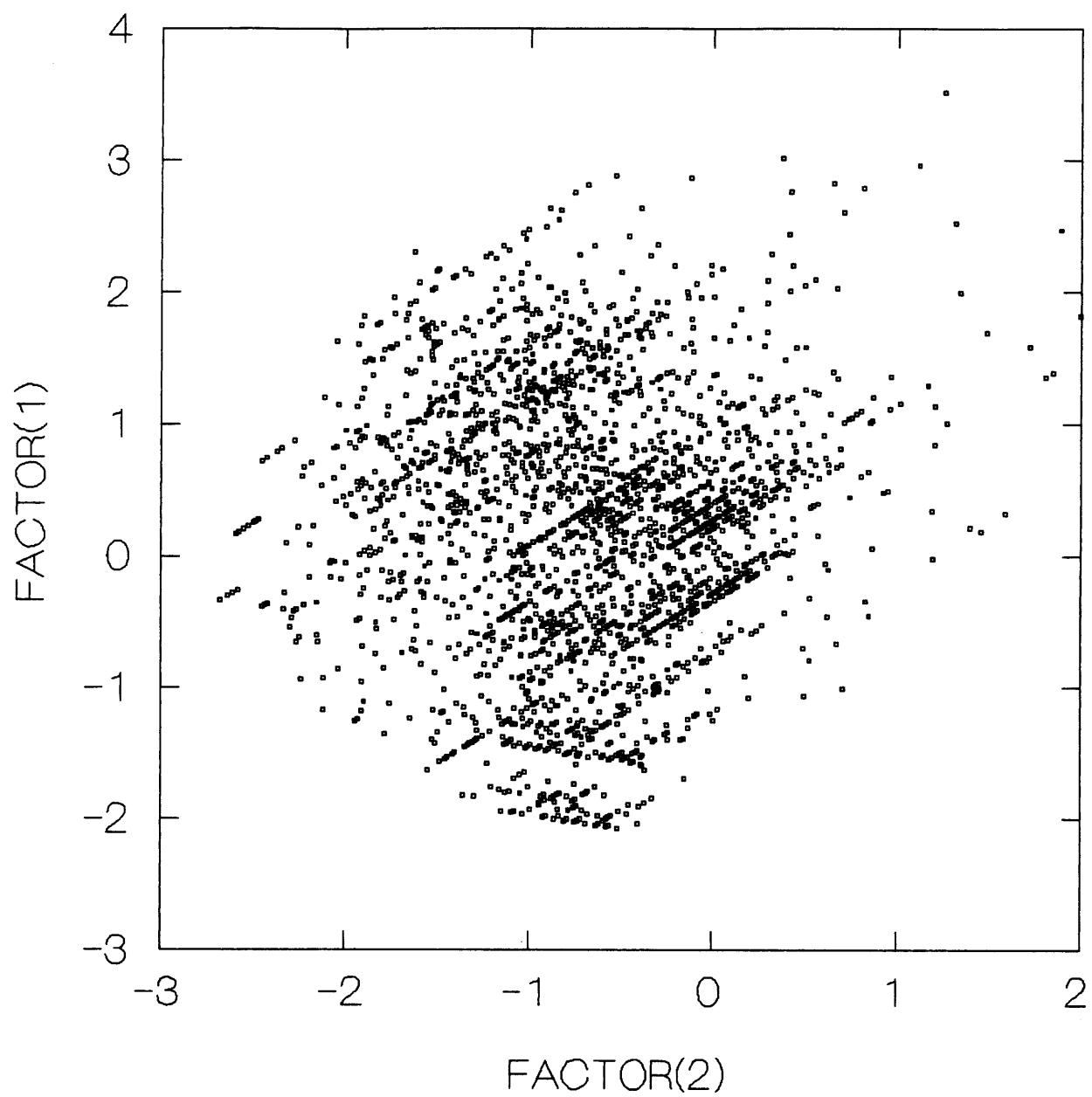


FIGURE 3

FIGURE 4

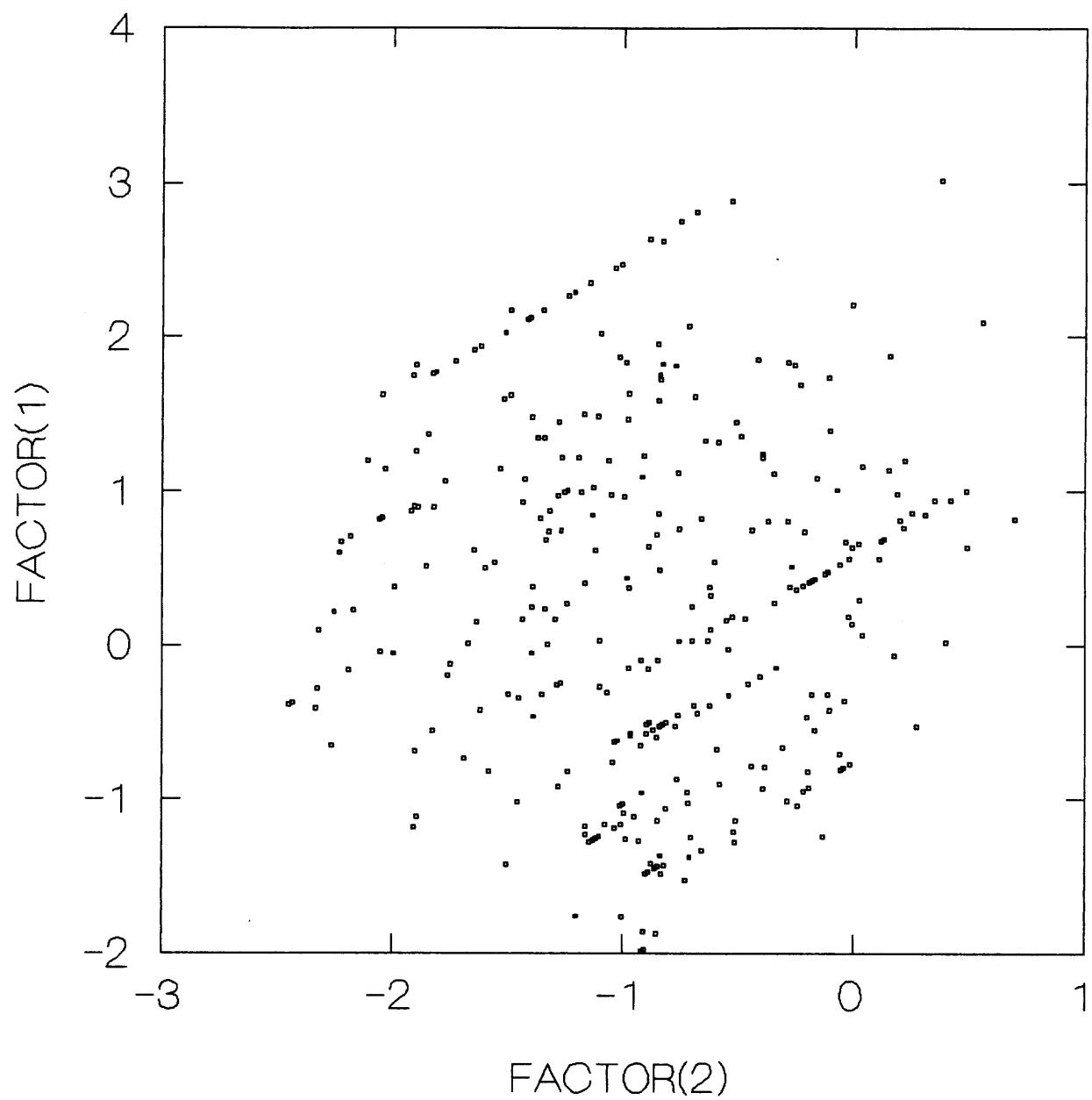


LCR Km 0 - 7.5
CONFLUENCE - SIPAPU

LOWER PCA

1-26-91

FIGURE 5

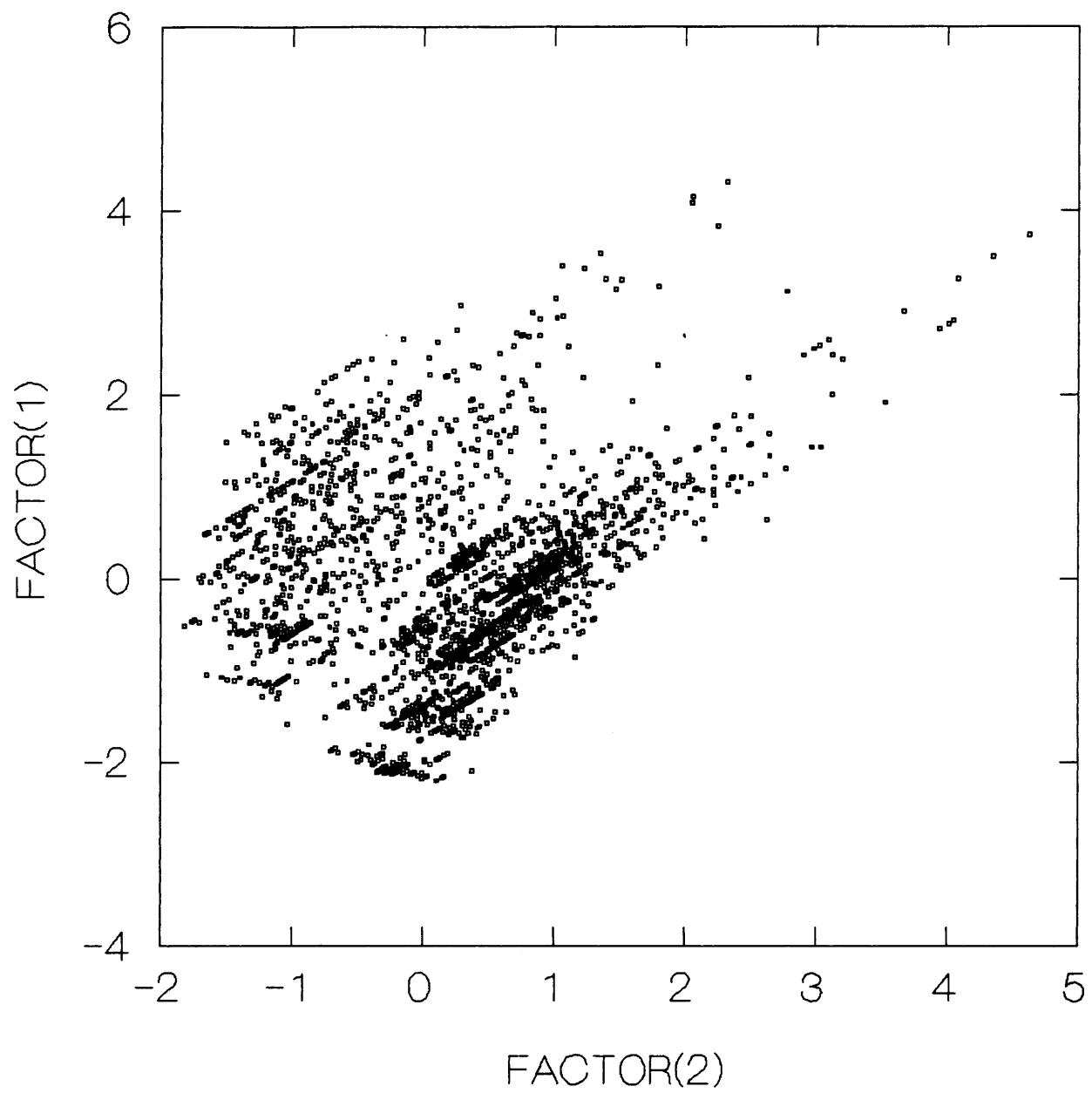


PCC, PCA

LCR Km 2.5-3.5

POWER CAMP STUDY AREA

FIGURE 6

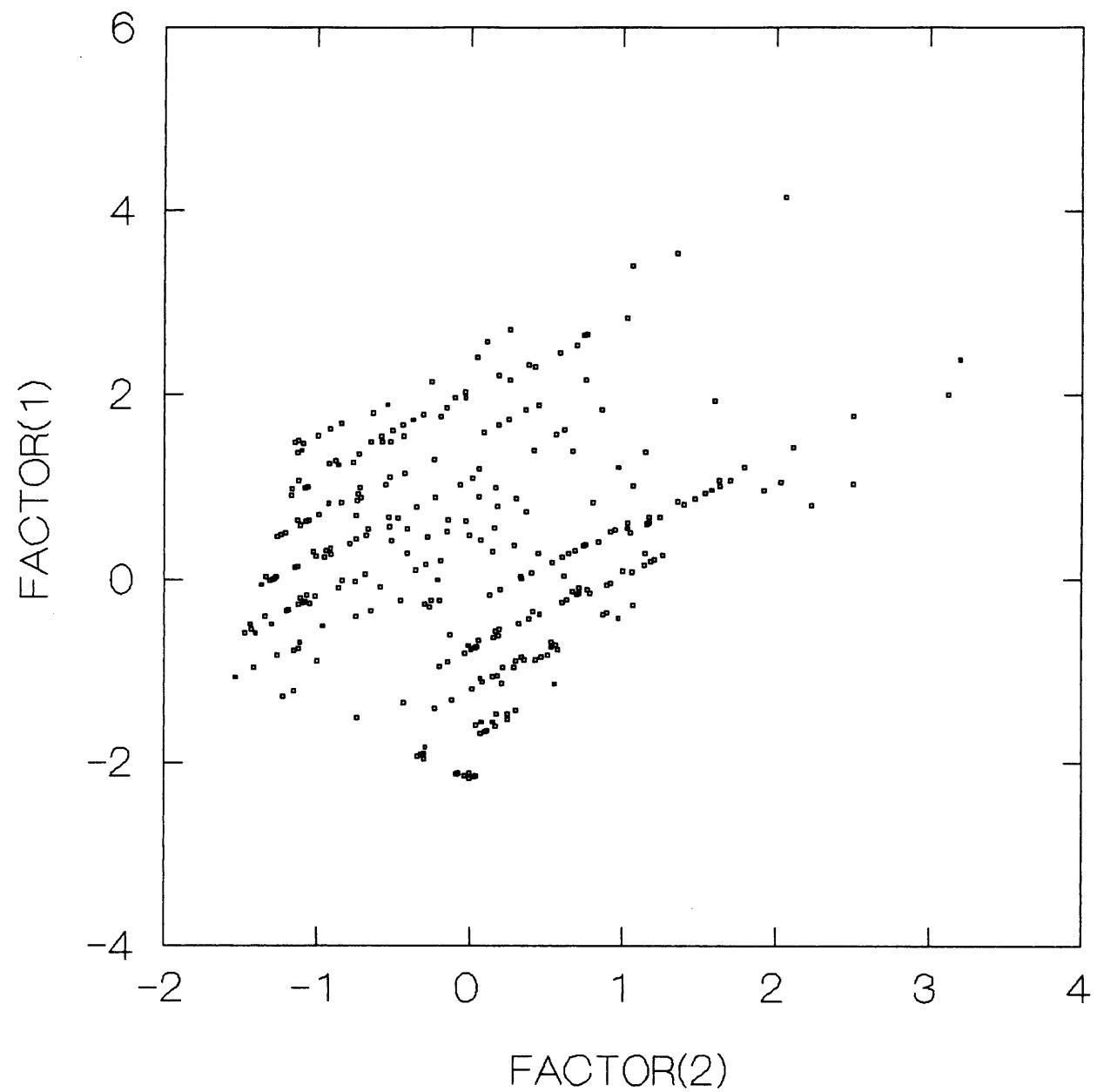


UPPER PCA

LCR km 8.0-14.5

SIPAPU - ATOMIZER

FIGURE 7

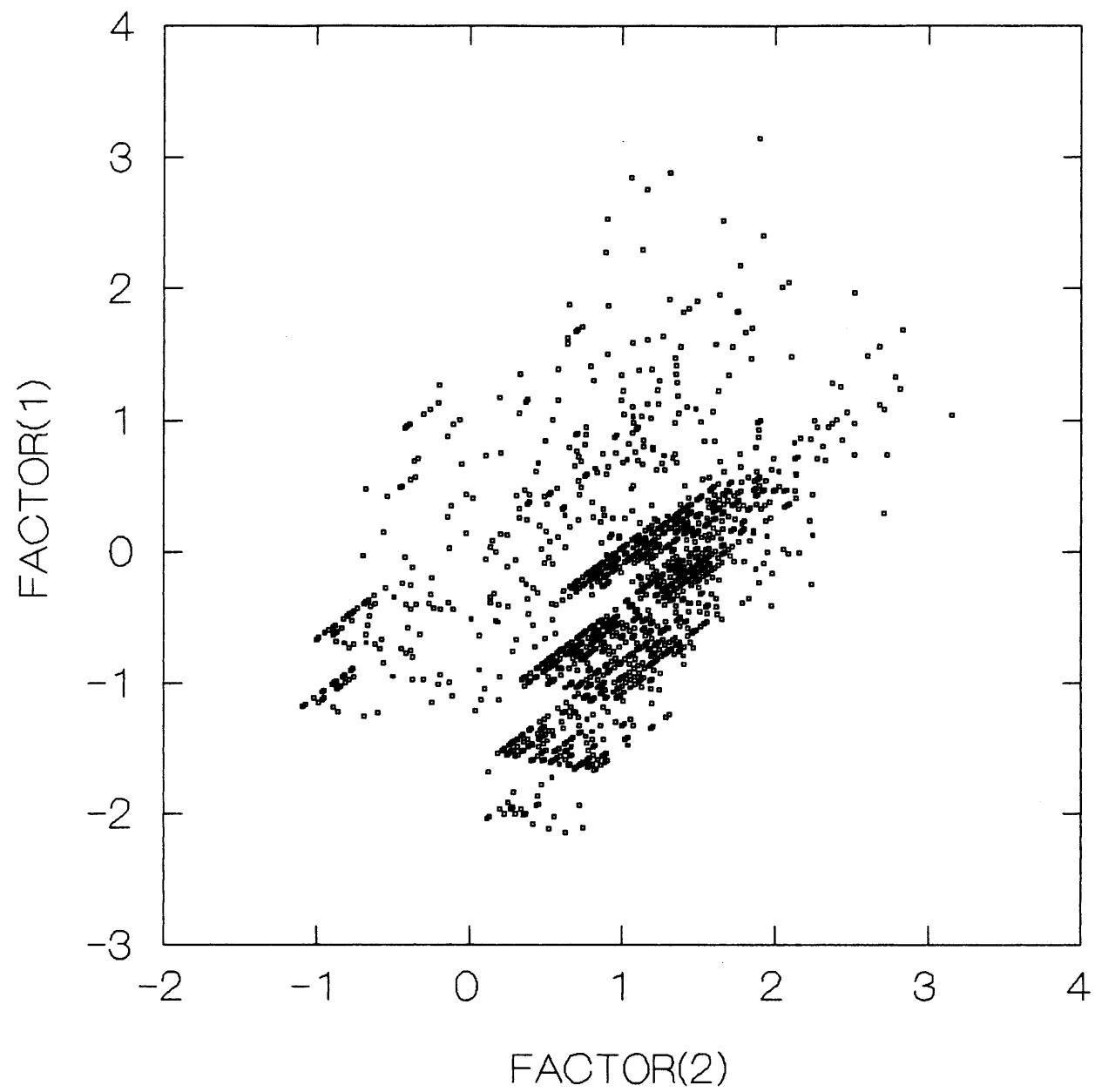


SCC PCA

LCR Km 10.5-11.5

SALT CAMP STUDY AREA

FIGURE 8



ACR Km 15 - 21

CHUTE FALLS - BLUE SPRINGS

BLSPR, MCA

APPENDIX A. Percent tables for depth, current, and substrate for the LCR, km 0-21, and for USFWS study areas. Row values 1-22 represent the km sections 0-21 of the LCR, 23 represents USFWS study area 1 (Powell Camp reach, km 2.5-3.5), and 24 represents USFWS study area 2 (Salt Camp reach, km 10.5-11.5). Column values represent categories for each habitat dimension. Depth was divided into twenty-one 10 cm categories from 0-200 cm and > 200 cm. Current is represented by 6 categories ranging from 0 (no current; column #1) to 5 (torrent; column #6). Substrate is an alluvial series represented by 11 categories from 0 (silt; column #1) to 10 (travertine; column #11). Habitat variables and categories are described in Gorman and Karr (1978) and Gorman (1988).

PERCENT TABLE FOR SYSTAT FILE DEPTH

APPENDIX A.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	sum row freq
1	4.55	10.00	22.73	3.64	6.36	4.55	7.27	10.00	13.64	4.55	1.82	1.82	1.82	0.91	2.73	0.00	0.00	0.91	0.00	0.91	1.82	110
2	16.20	6.85	11.84	10.28	14.64	9.35	9.97	5.30	5.61	1.25	3.43	2.49	1.25	0.62	0.00	0.00	0.31	0.00	0.31	0.00	0.31	321
3	17.37	12.87	9.28	8.08	9.88	10.18	9.58	5.39	5.09	3.59	3.29	2.99	1.80	0.30	0.30	0.00	0.00	0.00	0.00	0.00	0.00	334
4	22.96	12.99	15.71	9.06	13.29	5.74	5.44	4.23	3.63	3.02	1.51	0.91	0.30	0.60	0.60	0.00	0.00	0.00	0.00	0.00	0.00	331
5	17.26	11.73	10.42	8.47	15.31	11.07	9.12	5.54	4.56	1.95	2.28	0.98	0.65	0.00	0.33	0.33	0.00	0.00	0.00	0.00	0.00	307
6	10.96	7.97	9.63	5.98	14.95	18.60	11.96	6.98	6.98	1.99	0.33	1.33	0.66	0.33	0.00	0.33	0.33	0.00	0.33	0.00	0.00	301
7	17.34	6.07	9.54	12.43	15.90	10.40	8.96	6.07	5.78	2.31	1.73	0.87	1.45	0.29	0.29	0.58	0.00	0.00	0.00	0.00	0.00	346
8	15.54	11.78	9.02	14.79	11.53	13.78	9.27	6.02	2.51	2.26	1.25	0.75	0.50	0.25	0.00	0.00	0.25	0.50	0.00	0.00	0.00	399
9	15.54	9.32	10.17	11.02	8.47	11.30	12.15	8.76	4.24	1.41	1.69	0.85	0.28	0.28	0.28	0.56	0.28	0.85	0.56	0.28	1.69	354
10	20.20	12.37	6.31	11.87	9.60	11.87	5.05	7.32	4.55	2.53	1.01	2.27	1.52	0.00	1.26	0.51	0.00	0.25	0.51	0.00	1.01	396
11	16.36	8.48	11.21	13.94	11.21	10.91	5.76	7.27	4.55	4.24	1.52	2.42	0.30	0.61	0.61	0.61	0.00	0.00	0.00	0.00	0.00	330
12	19.19	8.12	11.07	9.59	8.12	6.27	7.75	7.01	6.27	2.58	2.21	0.74	0.74	1.48	0.00	1.11	0.00	0.37	0.00	1.11	271	
13	18.88	6.83	4.82	7.63	5.62	6.02	4.02	6.83	8.43	6.02	4.82	4.42	3.61	2.81	2.01	0.80	2.41	0.80	0.40	0.80	2.01	249
14	11.04	11.99	9.78	10.09	13.56	7.26	9.46	5.68	7.26	3.47	1.58	2.84	1.58	0.95	1.26	0.32	0.95	0.63	0.00	0.32	0.00	317
15	10.67	12.36	10.67	13.76	9.83	14.89	7.87	3.09	3.09	2.25	1.69	1.69	0.56	0.84	0.84	0.28	1.12	0.28	0.28	0.28	3.65	356
16	18.46	19.40	15.25	13.94	8.47	7.72	5.46	1.51	1.51	1.69	1.32	2.26	0.56	0.38	0.56	0.19	0.19	0.00	0.56	0.38	0.19	531
17	13.27	13.76	12.29	18.67	15.48	6.88	6.88	7.86	2.21	2.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	407
18	11.06	8.51	12.77	8.09	13.62	11.49	9.36	5.96	5.11	4.26	1.70	0.85	3.40	2.55	0.43	0.43	0.00	0.00	0.00	0.00	0.00	235
19	13.92	13.50	8.02	5.91	11.81	6.75	10.13	8.44	8.86	4.22	1.69	1.27	0.84	1.69	1.27	0.42	0.00	0.00	0.00	0.00	0.00	237
20	9.20	5.75	9.58	15.33	18.01	12.64	9.96	4.60	4.21	4.98	1.15	1.53	0.77	0.38	1.53	0.00	0.00	0.00	0.38	0.00	0.00	261
21	13.33	8.89	13.02	21.90	23.49	9.21	3.17	3.81	1.90	0.95	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	315
22	15.84	13.86	9.90	17.82	17.82	3.96	2.97	4.95	1.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	101
23	21.04	15.27	12.97	6.63	10.09	6.34	7.78	5.19	6.05	3.46	2.59	1.15	0.29	0.58	0.58	0.00	0.00	0.00	0.00	0.00	0.00	347
24	19.44	7.21	9.72	9.09	7.52	6.58	7.21	6.27	6.27	3.45	1.57	1.25	1.57	0.00	1.57	0.00	0.63	0.31	1.57	0.00	1.57	319

PERCENT TABLE FOR SYSTAT FILE current

APPENDIX A.

	1	2	3	4	5	6	sum row	freq
1	54.55	5.45	7.27	20.91	10.00	1.82	110	
2	0.93	9.97	25.55	54.83	5.61	3.12	321	
3	2.99	6.59	17.96	52.99	14.37	5.09	334	
4	7.25	21.45	22.36	26.28	13.60	9.06	331	
5	3.91	15.31	22.48	32.90	13.03	12.38	307	
6	4.98	10.30	20.27	56.81	7.31	0.33	301	
7	8.67	11.27	21.97	47.40	5.78	4.91	346	
8	5.51	15.54	35.09	36.59	4.76	2.51	399	
9	6.21	23.45	31.92	30.79	3.95	3.67	354	
10	13.13	16.67	25.51	37.12	3.79	3.79	396	
11	8.48	16.67	23.33	40.00	8.48	3.03	330	
12	6.64	19.19	27.68	26.20	15.87	4.43	271	
13	4.82	20.08	34.94	27.31	6.43	6.43	249	
14	3.79	17.98	58.36	17.98	0.63	1.26	317	
15	3.09	20.22	24.16	44.38	5.90	2.25	356	
16	10.55	31.26	29.38	27.87	0.75	0.19	531	
17	5.90	17.44	33.17	43.24	0.25	0.00	407	
18	2.55	13.62	29.36	47.23	5.11	2.13	235	
19	1.27	22.78	32.07	35.86	6.33	1.69	237	
20	1.92	11.11	31.80	43.30	8.43	3.45	261	
21	0.63	9.84	36.83	45.71	4.76	2.22	315	
22	0.00	13.86	35.64	38.61	6.93	4.95	101	
23	6.92	22.48	23.05	25.07	10.66	11.82	347	
24	6.27	20.38	26.33	26.65	14.11	6.27	319	

PERCENT TABLE FOR SYSTAT FILE SUBSET_{RA97C}

APPENDIX A.

	1	2	3	4	5	6	7	8	9	10	11	sum row	freq
1	3.64	2.73	54.55	1.82	5.45	10.00	10.91	8.18	2.73	0.00	0.00	110	
2	4.67	2.49	46.73	4.05	0.93	1.87	6.85	16.82	8.41	0.00	7.17	321	
3	11.98	3.59	37.72	2.99	1.20	3.29	4.79	23.35	10.48	0.00	0.60	334	
4	10.57	6.34	30.21	0.91	6.34	8.76	6.65	12.69	1.81	0.00	15.71	331	
5	11.07	0.00	32.57	2.28	3.58	6.19	6.51	6.51	5.86	0.00	25.41	307	
6	8.31	0.66	54.15	2.33	7.31	5.32	4.65	9.97	5.65	0.00	1.66	301	
7	12.72	1.45	52.60	2.31	0.87	3.18	6.07	4.91	7.80	0.00	8.09	346	
8	12.03	0.25	45.11	1.00	0.75	1.25	2.76	6.27	6.27	0.00	24.31	399	
9	8.19	0.00	49.72	0.56	0.28	0.56	1.69	1.69	1.98	0.00	35.31	354	
10	36.87	1.26	35.61	1.77	0.76	1.26	1.52	3.28	2.53	0.00	15.15	396	
11	15.45	1.82	40.00	0.91	3.94	1.52	4.55	4.24	4.24	0.00	23.33	330	
12	10.33	0.00	29.52	1.11	0.37	4.80	3.32	4.43	12.18	0.00	33.95	271	
13	5.22	0.00	47.79	0.00	0.00	0.80	0.40	4.02	0.80	0.00	40.96	249	
14	6.31	0.00	74.13	0.63	0.00	0.00	0.00	1.26	1.26	16.40	317		
15	2.25	0.00	75.28	0.00	0.00	0.00	0.00	0.28	1.97	7.02	13.20	356	
16	0.00	0.00	72.32	0.00	0.00	0.00	0.00	0.19	1.13	0.94	25.42	531	
17	0.00	0.00	90.66	0.49	0.00	0.25	0.00	0.00	0.00	0.00	8.60	407	
18	0.00	0.00	82.98	0.43	0.00	0.00	1.28	1.28	0.00	0.00	14.04	235	
19	0.00	0.00	73.84	2.11	0.42	3.38	8.02	5.06	3.38	0.00	3.80	237	
20	0.00	0.00	64.37	3.45	3.83	3.45	6.90	11.49	4.98	0.00	1.53	261	
21	0.00	0.00	75.56	3.17	1.90	5.40	6.98	1.90	0.00	1.90	0.00	315	
22	0.00	0.00	59.41	6.93	2.97	4.95	7.92	7.92	5.94	0.99	2.97	101	
23	10.66	6.05	29.11	1.15	4.90	8.07	6.34	10.95	2.02	0.00	20.75	347	
24	9.09	0.00	32.60	0.94	0.31	3.13	2.82	4.08	10.97	0.00	36.05	319	

APPENDIX B. Similarity matrices for depth, current, substrate, and combined dimensions (mean) for the LCR, km 0-21, and for USFWS study areas. PS measures in the cells were determined with Schoener's (1970) algorithm. Row and column values 0-21 represent the km sections 0-21 of the LCR, 22 represents USFWS study area 1 (Powell Camp reach, km 2.5-3.5), and 23 represents USFWS study area 2 (Salt Camp reach, km 10.5-11.5).

SIMILARITY MATRIX FOR DEPTH

APPENDIX B.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	mean
0	0.63	0.66	0.65	0.63	0.63	0.61	0.59	0.66	0.62	0.65	0.71	0.66	0.71	0.63	0.60	0.61	0.69	0.73	0.60	0.51	0.55	0.68	0.70	0.64	
1	0.63	0.88	0.81	0.90	0.83	0.91	0.84	0.85	0.80	0.87	0.85	0.72	0.86	0.78	0.76	0.79	0.86	0.80	0.83	0.76	0.79	0.82	0.83	0.82	
2	0.66	0.88	0.83	0.92	0.79	0.87	0.87	0.85	0.86	0.85	0.75	0.88	0.81	0.79	0.77	0.85	0.86	0.78	0.69	0.79	0.89	0.85	0.85	0.82	
3	0.65	0.81	0.83	0.85	0.71	0.80	0.80	0.76	0.82	0.82	0.68	0.81	0.76	0.84	0.81	0.79	0.79	0.72	0.73	0.81	0.90	0.79	0.79	0.79	
4	0.63	0.90	0.92	0.85	0.84	0.92	0.89	0.87	0.85	0.87	0.83	0.69	0.87	0.82	0.78	0.83	0.88	0.83	0.82	0.76	0.83	0.86	0.80	0.83	
5	0.63	0.83	0.79	0.71	0.84	0.83	0.81	0.82	0.74	0.74	0.79	0.75	0.64	0.83	0.79	0.64	0.74	0.85	0.81	0.82	0.69	0.70	0.74	0.73	0.76
6	0.61	0.91	0.87	0.80	0.92	0.83	0.87	0.86	0.84	0.89	0.83	0.71	0.85	0.79	0.75	0.81	0.86	0.81	0.87	0.77	0.82	0.81	0.82	0.82	
7	0.59	0.84	0.87	0.80	0.89	0.81	0.87	0.87	0.86	0.88	0.78	0.65	0.83	0.88	0.80	0.85	0.82	0.81	0.85	0.77	0.84	0.80	0.76	0.81	
8	0.66	0.85	0.85	0.76	0.87	0.82	0.86	0.87	0.85	0.87	0.83	0.70	0.82	0.83	0.77	0.77	0.83	0.81	0.79	0.71	0.75	0.78	0.81	0.80	
9	0.62	0.80	0.87	0.82	0.85	0.74	0.84	0.86	0.85	0.88	0.83	0.76	0.81	0.82	0.80	0.77	0.77	0.80	0.76	0.69	0.77	0.82	0.82	0.80	
10	0.65	0.87	0.86	0.82	0.87	0.79	0.89	0.88	0.87	0.88	0.86	0.73	0.83	0.84	0.81	0.83	0.86	0.81	0.83	0.78	0.83	0.82	0.83	0.83	
11	0.71	0.85	0.85	0.82	0.83	0.75	0.83	0.78	0.83	0.86	0.83	0.84	0.78	0.78	0.75	0.81	0.82	0.76	0.67	0.75	0.87	0.95	0.81	0.82	
12	0.66	0.72	0.75	0.68	0.69	0.64	0.71	0.65	0.70	0.76	0.73	0.83	0.73	0.64	0.65	0.60	0.71	0.75	0.63	0.54	0.64	0.73	0.87	0.70	
13	0.71	0.86	0.88	0.81	0.87	0.83	0.85	0.83	0.82	0.81	0.83	0.84	0.73	0.83	0.75	0.81	0.88	0.88	0.82	0.71	0.79	0.83	0.83	0.82	
14	0.63	0.78	0.81	0.76	0.82	0.79	0.79	0.88	0.83	0.82	0.84	0.78	0.64	0.83	0.79	0.79	0.81	0.76	0.82	0.72	0.78	0.77	0.75	0.78	
15	0.60	0.76	0.79	0.84	0.78	0.64	0.75	0.80	0.77	0.80	0.81	0.78	0.65	0.75	0.79	0.79	0.71	0.71	0.69	0.73	0.80	0.82	0.75	0.75	
16	0.61	0.79	0.77	0.81	0.83	0.74	0.81	0.85	0.77	0.77	0.83	0.75	0.60	0.81	0.79	0.79	0.78	0.79	0.79	0.85	0.89	0.79	0.71	0.78	
17	0.69	0.86	0.85	0.79	0.88	0.85	0.86	0.82	0.83	0.77	0.86	0.81	0.71	0.88	0.81	0.71	0.78	0.83	0.84	0.73	0.75	0.81	0.79	0.80	
18	0.73	0.80	0.86	0.79	0.83	0.81	0.81	0.81	0.80	0.81	0.80	0.82	0.75	0.88	0.76	0.71	0.79	0.83	0.76	0.65	0.76	0.85	0.80	0.79	
19	0.60	0.83	0.78	0.72	0.82	0.87	0.85	0.79	0.79	0.83	0.76	0.63	0.82	0.82	0.69	0.79	0.84	0.76	0.77	0.82	0.71	0.74	0.77	0.77	
20	0.51	0.76	0.69	0.73	0.76	0.69	0.77	0.77	0.71	0.69	0.78	0.67	0.54	0.71	0.72	0.73	0.85	0.73	0.65	0.77	0.85	0.68	0.64	0.71	
21	0.55	0.79	0.79	0.81	0.83	0.70	0.82	0.84	0.75	0.77	0.83	0.75	0.64	0.79	0.78	0.80	0.89	0.75	0.76	0.82	0.85	0.78	0.73	0.77	
22	0.58	0.82	0.89	0.90	0.86	0.74	0.81	0.80	0.78	0.82	0.87	0.73	0.83	0.77	0.82	0.79	0.81	0.85	0.71	0.68	0.78	0.84	0.80	0.80	
23	0.70	0.83	0.85	0.79	0.80	0.73	0.82	0.76	0.81	0.82	0.83	0.95	0.87	0.83	0.75	0.75	0.71	0.79	0.80	0.74	0.64	0.73	0.84	0.79	

grand sum of similarity values 216.21
mean similarity value 0.78

max. value = 276

SIMILARITY MATRIX FOR current

APPENDIX B.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	mean
0	0.42	0.48	0.53	0.49	0.46	0.50	0.46	0.46	0.52	0.52	0.47	0.36	0.44	0.45	0.40	0.43	0.46	0.41	0.42	0.52	0.52	0.52	0.46		
1	0.42	0.87	0.68	0.75	0.92	0.89	0.80	0.74	0.80	0.83	0.71	0.72	0.56	0.87	0.65	0.80	0.91	0.80	0.88	0.89	0.83	0.68	0.72	0.77	
2	0.48	0.87	0.73	0.79	0.88	0.86	0.71	0.66	0.72	0.79	0.73	0.66	0.47	0.80	0.56	0.71	0.82	0.70	0.82	0.78	0.75	0.68	0.73	0.73	
3	0.53	0.68	0.73	0.90	0.69	0.77	0.77	0.84	0.80	0.84	0.92	0.86	0.64	0.80	0.78	0.72	0.72	0.79	0.74	0.66	0.74	0.96	0.95	0.78	
4	0.49	0.75	0.79	0.90	0.75	0.81	0.82	0.80	0.82	0.86	0.85	0.82	0.61	0.82	0.71	0.75	0.79	0.80	0.80	0.73	0.81	0.89	0.88	0.78	
5	0.46	0.92	0.88	0.69	0.75	0.89	0.77	0.71	0.77	0.83	0.69	0.69	0.53	0.84	0.64	0.79	0.86	0.74	0.83	0.82	0.76	0.68	0.70	0.75	
6	0.50	0.89	0.86	0.77	0.81	0.89	0.83	0.78	0.87	0.91	0.76	0.76	0.57	0.89	0.71	0.83	0.90	0.78	0.88	0.85	0.83	0.76	0.77	0.80	
7	0.46	0.80	0.71	0.77	0.82	0.77	0.83	0.90	0.89	0.88	0.82	0.90	0.74	0.86	0.79	0.91	0.89	0.91	0.89	0.89	0.93	0.76	0.81	0.82	
8	0.46	0.74	0.66	0.84	0.80	0.71	0.78	0.90	0.87	0.84	0.87	0.92	0.74	0.84	0.88	0.86	0.82	0.92	0.83	0.79	0.84	0.84	0.87	0.81	
9	0.52	0.80	0.72	0.80	0.82	0.77	0.87	0.89	0.87	0.92	0.84	0.84	0.74	0.84	0.88	0.86	0.82	0.92	0.83	0.79	0.84	0.79	0.83	0.81	
10	0.52	0.83	0.79	0.84	0.86	0.83	0.91	0.88	0.84	0.92	0.84	0.82	0.64	0.91	0.77	0.86	0.87	0.85	0.88	0.81	0.86	0.83	0.84	0.83	
11	0.52	0.71	0.73	0.92	0.85	0.69	0.76	0.82	0.87	0.83	0.84	0.89	0.69	0.81	0.81	0.77	0.77	0.82	0.79	0.71	0.79	0.89	0.97	0.79	
12	0.47	0.72	0.66	0.86	0.82	0.69	0.76	0.90	0.92	0.82	0.82	0.89	0.77	0.83	0.83	0.80	0.89	0.82	0.80	0.87	0.86	0.91	0.81	0.81	
13	0.36	0.56	0.47	0.64	0.61	0.53	0.57	0.74	0.74	0.66	0.64	0.69	0.77	0.65	0.70	0.73	0.65	0.71	0.65	0.67	0.69	0.65	0.68	0.64	
14	0.44	0.87	0.80	0.80	0.82	0.84	0.89	0.86	0.84	0.87	0.91	0.81	0.83	0.65	0.76	0.88	0.92	0.89	0.86	0.85	0.80	0.82	0.82	0.82	
15	0.45	0.65	0.56	0.78	0.71	0.64	0.71	0.79	0.88	0.82	0.77	0.81	0.83	0.70	0.76	0.81	0.74	0.82	0.71	0.69	0.72	0.78	0.81	0.74	
16	0.40	0.80	0.71	0.72	0.75	0.79	0.83	0.91	0.86	0.85	0.86	0.77	0.83	0.73	0.88	0.81	0.89	0.87	0.88	0.87	0.86	0.72	0.77	0.80	
17	0.43	0.91	0.82	0.72	0.79	0.86	0.90	0.89	0.82	0.85	0.87	0.77	0.80	0.65	0.92	0.74	0.89	0.87	0.93	0.92	0.89	0.72	0.76	0.81	
18	0.43	0.80	0.70	0.79	0.80	0.74	0.78	0.91	0.92	0.85	0.85	0.82	0.89	0.71	0.89	0.82	0.87	0.87	0.88	0.85	0.90	0.80	0.83	0.81	
19	0.46	0.88	0.82	0.74	0.80	0.83	0.88	0.89	0.83	0.83	0.88	0.79	0.82	0.65	0.89	0.71	0.88	0.93	0.88	0.93	0.92	0.73	0.78	0.81	
20	0.41	0.89	0.78	0.66	0.73	0.82	0.85	0.89	0.79	0.79	0.81	0.71	0.80	0.67	0.86	0.69	0.87	0.92	0.85	0.93	0.91	0.66	0.70	0.78	
21	0.42	0.83	0.75	0.74	0.81	0.76	0.83	0.93	0.84	0.84	0.86	0.79	0.87	0.69	0.85	0.72	0.86	0.89	0.90	0.92	0.91	0.74	0.79	0.81	
22	0.52	0.68	0.96	0.89	0.68	0.76	0.76	0.84	0.79	0.83	0.89	0.86	0.65	0.80	0.78	0.72	0.80	0.73	0.66	0.74	0.92	0.77	0.92	0.77	
23	0.52	0.72	0.73	0.95	0.88	0.70	0.77	0.81	0.87	0.83	0.84	0.97	0.91	0.68	0.82	0.81	0.77	0.76	0.83	0.78	0.70	0.79	0.92	0.80	

grand sum of similarity values 213.17
mean similarity value 0.77

SIMILARITY MATRIX FOR SUBJECTS

APPENDIX B.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	mean
0	0.75	0.66	0.68	0.64	0.87	0.77	0.64	0.60	0.52	0.63	0.50	0.55	0.60	0.59	0.56	0.55	0.58	0.76	0.81	0.76	0.83	0.66	0.50	0.65	
1	0.75	0.81	0.69	0.68	0.79	0.84	0.75	0.65	0.60	0.70	0.61	0.64	0.60	0.58	0.55	0.55	0.57	0.70	0.78	0.69	0.77	0.67	0.63	0.68	
2	0.66	0.81	0.70	0.68	0.74	0.76	0.69	0.53	0.61	0.69	0.63	0.49	0.47	0.43	0.40	0.39	0.41	0.57	0.67	0.58	0.64	0.67	0.64	0.60	
3	0.68	0.69	0.70	0.82	0.70	0.68	0.70	0.61	0.67	0.75	0.71	0.54	0.54	0.48	0.47	0.40	0.47	0.52	0.60	0.52	0.58	0.94	0.68	0.63	
4	0.64	0.68	0.68	0.82	0.71	0.75	0.86	0.73	0.70	0.86	0.85	0.68	0.57	0.50	0.59	0.42	0.50	0.57	0.61	0.56	0.65	0.86	0.84	0.68	
5	0.87	0.79	0.74	0.70	0.71	0.85	0.73	0.66	0.57	0.70	0.59	0.60	0.64	0.60	0.57	0.57	0.59	0.75	0.85	0.77	0.84	0.68	0.60	0.69	
6	0.77	0.84	0.76	0.68	0.75	0.85	0.82	0.73	0.69	0.79	0.68	0.66	0.69	0.65	0.62	0.61	0.64	0.76	0.76	0.72	0.79	0.68	0.69	0.72	
7	0.64	0.75	0.69	0.70	0.86	0.73	0.82	0.84	0.73	0.90	0.80	0.80	0.70	0.63	0.71	0.54	0.62	0.63	0.64	0.61	0.66	0.75	0.82	0.72	
8	0.60	0.65	0.53	0.61	0.73	0.66	0.73	0.84	0.66	0.78	0.78	0.92	0.74	0.67	0.76	0.59	0.67	0.60	0.58	0.59	0.65	0.83	0.69		
9	0.52	0.60	0.61	0.67	0.70	0.57	0.69	0.73	0.66	0.78	0.65	0.60	0.59	0.53	0.52	0.45	0.53	0.50	0.48	0.48	0.50	0.66	0.67	0.59	
10	0.63	0.70	0.69	0.75	0.86	0.70	0.79	0.90	0.78	0.78	0.74	0.65	0.58	0.65	0.49	0.57	0.59	0.61	0.58	0.61	0.80	0.79	0.70		
11	0.50	0.61	0.63	0.71	0.85	0.59	0.68	0.80	0.78	0.65	0.78	0.74	0.54	0.47	0.56	0.39	0.47	0.49	0.44	0.52	0.76	0.95	0.63		
12	0.55	0.64	0.49	0.54	0.68	0.60	0.66	0.80	0.92	0.60	0.74	0.74	0.71	0.66	0.75	0.56	0.63	0.56	0.55	0.53	0.57	0.58	0.79	0.65	
13	0.60	0.60	0.47	0.54	0.57	0.64	0.69	0.70	0.74	0.59	0.65	0.54	0.71	0.92	0.91	0.83	0.89	0.80	0.68	0.78	0.65	0.54	0.57	0.68	
14	0.59	0.58	0.43	0.48	0.50	0.60	0.65	0.63	0.67	0.53	0.58	0.47	0.66	0.92	0.88	0.84	0.89	0.80	0.68	0.79	0.66	0.47	0.50	0.64	
15	0.56	0.55	0.40	0.47	0.59	0.57	0.62	0.71	0.76	0.52	0.65	0.56	0.75	0.91	0.88	0.81	0.87	0.77	0.67	0.76	0.65	0.51	0.59	0.66	
16	0.55	0.55	0.39	0.40	0.42	0.57	0.61	0.54	0.59	0.45	0.49	0.39	0.56	0.83	0.84	0.81	0.92	0.78	0.67	0.78	0.63	0.38	0.42	0.59	
17	0.58	0.57	0.41	0.47	0.50	0.59	0.64	0.62	0.67	0.53	0.57	0.47	0.63	0.89	0.89	0.87	0.92	0.81	0.69	0.80	0.65	0.46	0.50	0.64	
18	0.76	0.70	0.57	0.52	0.57	0.75	0.76	0.63	0.60	0.50	0.59	0.49	0.56	0.80	0.80	0.77	0.78	0.81	0.87	0.93	0.85	0.51	0.51	0.68	
19	0.81	0.78	0.67	0.60	0.61	0.85	0.76	0.64	0.58	0.48	0.61	0.49	0.55	0.68	0.68	0.67	0.67	0.69	0.87	0.88	0.91	0.58	0.50	0.68	
20	0.76	0.69	0.58	0.52	0.56	0.77	0.72	0.61	0.58	0.48	0.58	0.44	0.53	0.78	0.79	0.76	0.78	0.80	0.93	0.88	0.84	0.52	0.46	0.67	
21	0.83	0.77	0.64	0.58	0.65	0.84	0.79	0.66	0.59	0.50	0.61	0.52	0.57	0.65	0.66	0.65	0.63	0.65	0.85	0.91	0.84	0.57	0.53	0.67	
22	0.66	0.67	0.67	0.94	0.86	0.68	0.68	0.75	0.65	0.66	0.80	0.76	0.58	0.54	0.47	0.51	0.38	0.46	0.51	0.58	0.52	0.57	0.72	0.64	
23	0.50	0.63	0.64	0.68	0.84	0.60	0.69	0.82	0.83	0.67	0.79	0.95	0.79	0.57	0.50	0.59	0.42	0.50	0.51	0.50	0.46	0.53	0.72	0.64	

grand sum of similarity values 181.88
mean similarity value 0.66
max. value = 276

APPENDIX B .

SIMILARITY MATRIX FOR mean (DCS)

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	mean
0	0.60	0.60	0.62	0.59	0.65	0.63	0.56	0.57	0.55	0.60	0.58	0.56	0.56	0.56	0.54	0.52	0.56	0.64	0.63	0.56	0.60	0.62	0.57	0.59	
1	0.60	-	0.86	0.73	0.78	0.85	0.88	0.80	0.75	0.73	0.80	0.72	0.69	0.68	0.75	0.66	0.71	0.78	0.77	0.83	0.78	0.80	0.72	0.73	0.76
2	0.60	0.86	-	0.75	0.79	0.81	0.83	0.76	0.68	0.73	0.78	0.74	0.63	0.60	0.68	0.58	0.63	0.69	0.71	0.76	0.68	0.73	0.75	0.74	0.72
3	0.62	0.73	0.75	-	0.86	0.70	0.75	0.76	0.74	0.76	0.81	0.82	0.70	0.66	0.68	0.70	0.64	0.66	0.70	0.69	0.64	0.71	0.93	0.81	0.73
4	0.59	0.78	0.79	0.86	-	0.76	0.82	0.86	0.80	0.79	0.86	0.84	0.73	0.69	0.71	0.69	0.66	0.72	0.74	0.75	0.68	0.76	0.87	0.84	0.77
5	0.65	0.85	0.81	0.70	0.76	-	0.86	0.77	0.73	0.69	0.77	0.68	0.64	0.67	0.74	0.62	0.70	0.76	0.77	0.83	0.76	0.77	0.70	0.67	0.74
6	0.63	0.88	0.83	0.75	0.82	0.86	-	0.84	0.79	0.80	0.86	0.76	0.71	0.70	0.78	0.69	0.75	0.80	0.78	0.84	0.78	0.81	0.75	0.76	0.78
7	0.56	0.80	0.76	0.76	0.86	0.77	0.84	-	0.87	0.83	0.89	0.80	0.78	0.76	0.79	0.77	0.77	0.78	0.78	0.79	0.76	0.81	0.77	0.80	0.79
8	0.57	0.75	0.68	0.74	0.80	0.73	0.79	0.87	-	0.79	0.83	0.83	0.85	0.76	0.78	0.80	0.74	0.77	0.78	0.73	0.70	0.73	0.76	0.84	0.77
9	0.55	0.73	0.73	0.76	0.79	0.69	0.80	0.83	0.79	-	0.86	0.77	0.73	0.69	0.74	0.71	0.69	0.72	0.69	0.65	0.70	0.76	0.77	0.73	
10	0.60	0.80	0.78	0.81	0.86	0.77	0.86	0.89	0.83	0.86	-	0.83	0.76	0.70	0.77	0.74	0.73	0.76	0.75	0.77	0.72	0.77	0.82	0.82	0.78
11	0.58	0.72	0.74	0.82	0.84	0.68	0.76	0.80	0.83	0.77	0.83	-	0.82	0.69	0.69	0.72	0.64	0.68	0.71	0.68	0.61	0.69	0.84	0.96	0.74
12	0.56	0.69	0.63	0.70	0.73	0.64	0.71	0.78	0.85	0.73	0.76	0.82	-	0.74	0.71	0.74	0.66	0.71	0.73	0.66	0.62	0.69	0.72	0.85	0.72
13	0.56	0.68	0.60	0.66	0.69	0.67	0.70	0.76	0.76	0.69	0.70	0.69	0.74	-	0.80	0.78	0.79	0.81	0.80	0.72	0.72	0.71	0.67	0.69	0.71
14	0.56	0.75	0.68	0.68	0.71	0.74	0.78	0.79	0.78	0.74	0.77	0.69	0.71	0.80	-	0.81	0.84	0.87	0.82	0.80	0.79	0.76	0.68	0.69	0.75
15	0.54	0.66	0.58	0.70	0.69	0.62	0.69	0.77	0.80	0.71	0.74	0.72	0.74	0.78	0.81	-	0.80	0.77	0.77	0.69	0.72	0.72	0.71	0.72	0.72
16	0.52	0.71	0.63	0.64	0.66	0.70	0.75	0.77	0.74	0.69	0.73	0.64	0.66	0.79	0.84	-	0.86	0.81	0.78	0.84	0.79	0.76	0.63	0.63	0.72
17	0.56	0.78	0.69	0.66	0.72	0.76	0.80	0.78	0.77	0.72	0.75	0.71	0.73	0.80	0.82	0.77	0.81	0.87	0.77	0.86	0.83	0.82	0.76	0.66	0.75
18	0.64	0.77	0.71	0.70	0.74	0.77	0.78	0.78	0.72	0.75	0.71	0.73	0.80	0.82	0.77	0.81	0.83	0.84	0.81	0.83	0.72	0.71	0.76	0.71	0.76
19	0.63	0.83	0.76	0.69	0.75	0.83	0.84	0.79	0.73	0.69	0.77	0.68	0.66	0.72	0.80	0.69	0.78	0.82	0.84	0.86	0.88	0.68	0.68	0.75	
20	0.56	0.78	0.68	0.64	0.68	0.76	0.78	0.76	0.70	0.65	0.72	0.61	0.62	0.72	0.79	0.72	0.84	0.82	0.81	0.86	0.87	0.62	0.60	0.72	
21	0.60	0.80	0.73	0.71	0.76	0.77	0.81	0.81	0.73	0.70	0.77	0.69	0.71	0.76	0.72	0.79	0.76	0.83	0.88	0.87	0.70	0.68	0.75	0.75	
22	0.62	0.72	0.75	0.93	0.87	0.70	0.75	0.77	0.76	0.76	0.82	0.84	0.72	0.67	0.68	0.71	0.63	0.66	0.72	0.68	0.62	0.70	0.83	0.73	0.73
23	0.57	0.73	0.74	0.81	0.84	0.67	0.76	0.80	0.84	0.77	0.82	0.96	0.85	0.69	0.72	0.63	0.68	0.71	0.68	0.60	0.68	0.83	0.74	0.74	

grand sum of similarity values 203.75
mean similarity value 0.74

max. value = 276